ture. If this conjugate net has equal Laplace-Darboux invariants, a particular class of surfaces analogous to isothermic surfaces is defined. A projective generalization of geodesics may be made in terms of the congruence $y\zeta$, since[6] there exists a two-parameter family of curves on the surface whose osculating planes contain the lines $y\zeta$. It must be possible also to generalize a good part of the theory of triply orthogonal systems and families of Lamé, although the generalization can never be complete on account of the essential differences between metric and projective space. The field seems, on the whole, to be very promising.

[1] Green, G. M., *Trans. Amer. Math. Soc., New York,* **17,** 1916, (483–516).

[2] Wilczynski, E. J., *Ibid.,* **8,** 1907, (233–260).

[3] Idem, *Ibid.,* **9,** 1908, (79–120).

[4] Green, G. M., *Amer. J. Math., Baltimore,* **38,** 1916, (313).

[5] Darboux, *Bull. Sci. Math., Paris,* (Ser. 2), **4,** 1880, (348–384).

[6] Cf. the abstract of Miss P. Sperry, *Bull. Amer. Math. Soc., New York,* **22,** 1915–1916, (441–442). The normal congruence is there replaced by the directrix congruence of the second kind, whose developables, however, do not cut the surface in a conjugate net.

A CONTRIBUTION TO THE PETROGRAPHY OF SOUTHERN CELEBES

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In a paper in the *Journal of Geology,* Chicago, **23,** 1915, (231–245), the authors described some rocks collected in Java and Celebes in 1910. The chemical analyses of seven of these were from lavas and coarsely crystalline igneous rocks occurring in the neighborhood of Bulu Saraung (Pic de Maros). The rocks analyzed are trachytes, absarokite, nephelite-syenite and fergusite, besides kentallenite and marosite, rocks related to shonkinite.

In November, 1914, a more extended visit was made to Southern Celebes under the auspices of the Bureau of Mines of the Netherlands Government. The mountainous region from Maros to Malawa and Batuku was studied in company with Mr. 'T Hoen and Mr. Ziegler, geologists of the Bureau. The region visited consists of several nearly parallel ranges of volcanic mountains, whose lavas are underlaid by faulted and dislocated strata which are exposed in the valleys and along the base of the volcanic ridges.

The faulting and dislocation of the limestones and coal-bearing shales antedated the eruption of the igneous rocks, for the distorted strata are overlaid by volcanic breccias which form much less disturbed beds

in nearly horizontal positions in some parts of the region, but have dome-like positions in other places where great bodies of intruded lavas have lifted the sedimentary strata and overlying breccias, and have formed large laccolithic masses. The sedimentary strata are also traversed by intrusive sheets or sills of igneous rocks which occupy slightly different horizons in adjacent blocks of faulted sediments, showing that their intrusion was subsequent to the faulting and dislocation of the sedimentary strata. Dikes of igneous rocks occur more abundantly in some localities than in others, but are not very numerous.

The volcanic breccias, which are probably the oldest eruptions of the series in this region, vary somewhat in different localities and in different parts of one mountain ridge. For the most part they are basaltic in appearance with small phenocrysts of augite and olivine, and very few of feldspar. The more feldspathic varieties occur chiefly in the breccia mountains heading the valley north of Bulu Saraung, that is, the southwestern end of the region visited. These rocks are mostly trachy-andesites, with small phenocrysts of augite and calcic plagioclase, in a groundmass of more alkalic feldspar which is in part orthoclase. With these andisitic breccias are associated more basaltic varieties and smaller amounts of trachytic rocks, some of which contain leucite. While most of this breccia is without noticeable bedding, is chaotic, parts of it are distinctly bedded and contain well-worn pebbles of the same kinds of rock as those forming the chaotic breccia.

Farther north-east, in the vicinity of Malawa and Batuku, the breccia is almost wholly basaltic, with phenocrysts of augite and olivine; some varieties containing abundant small leucites, some being rich in large leucites. Leucitophyres constitute a great part of the volcanic breccias of the ridges visited, and are said to occur throughout a range of mountains at least 60 miles in length. Leucite-bearing rocks have been found in scattered localities from the Saleier Islands at the southern extremity of Celebes to the northern end, a distance of about 500 miles.

Large bodies of lava have broken through the volcanic breccias in places, and have formed masses of trachyte and phonolite. This is the case especially in the southwest. The summit of Bulu Saraung (Pic de Maros) is phonolite which is younger than the basaltic breccias and tuffs that form the ridge to the east. Other large bodies of massive lava form peaks north of the road nead Bua. Dikes of porphyritic trachyte, and of other kinds of rocks, cut the breccias and sedimentary strata beneath them. A large dike of trachyte cuts limestone in the valley of the Sangara (Gentungen) above Balotji. It is exposed in a wall 6 feet thick and 30 feet high. Intrusive sills occur in the stratified

rocks and at the base of the breccias, and have a wide range of composition. Great sheets of basalt form cliffs with limestone west of Maros near Patinuan. West of Birau, which is north of B. Saraung, there are sills of fine-grained syenite and leucitophyre. Leucitophyres form sills in the coal-bearing strata near Batuku. Laccolithic bodies of great size occur at the west base of B. Saraung, also in the valley east of Tjamba, and in the valley of Malawa. The rocks forming the laccoliths vary somewhat in composition and in grain. The largest are shonkinites, fergusite and essexite, which merge at their margins into fine-grained and aphanitic porphyries, with small porphyritic leucites. Other laccolithic bodies are medium to fine-grained rocks, some of which are more feldspathic than the shonkinites, and approach monzonites and syenites. There are phases of the laccolithic rocks very rich in biotite, augite and olivine, and others, occurring as veins in the principal rocks, that are syenites and nephelite-syenites. In contrast to these feldspathic rocks are highly mafic lavas, found as boulders in streams, which consist almost wholly of augite and olivine.

While some parts of the igneous rocks in this region are much decomposed, the great majority of the boulders in the streams, and of massive exposures in place, are extremely fresh, even the crystals of leucite and olivine, although the lavas were probably erupted in late Tertiary times. This may be due to the absence of frost and the vigorous surface action of abundant rains and strongly flooded streams.

A large collection of rocks from the localities visited shows the great variety of leucitic lavas and the freshness of the rocks in most instances. The accompanying chemical analyses of twelve specimens illustrate the most interesting varieties so far studied. In addition to the seven analyses previously published in the *Journal of Geology*, and those published and described by A. Schmidt, they furnish a fair idea of the chemical composition of the igneous rocks of this part of Celebes.

Analysis 1 is of a non-porphyritic trachytic phonolite, which forms the summit of Bulu Saraung (Pic de Maros). It is holocrystalline with a trachytoid texture, and consists of prismoid alkalic feldspar with abundant minute crystals of what is probably sodalite. There is a small amount of brownish green pyroxene, which is slightly pleochroic, colorless wallastonite, and euhedral magnetite. Analysis 2 is of a porphyritic pseudoleucite-trachyte, with large phenocrysts of altered leucite, now analcite, and fewer of orthoclase and plagioclase. Analysis 3 is of a porphypitic leucite-trachyte with phenocrysts of augite, biotite and altered leucite, in a groundmass of alkalic feldspar and biotite.

Analysis 4 is of a leucitophyre from Batuku. The phenocrysts of

leucite are large and fresh,—also of various sizes, to microscopic dimensions. The groundmass consists of small augites, prismoids of alkalic feldspar, magnetite and blades of ilmenite. Analysis 5 is of a minette, an aphanitic rock, with microscopic phenocrysts of biotite, magnetite, feldspar and augite, The groundmass consists of alkalic feldspar, biotite, augite and anhedral calcite, with some sodalite or altered leucite. The calcite is secondary.

The following six analyses are of shonkinites and leucitophyres. The shonkinites differ from one another, somewhat in composition, and might possibly be given different names. That from which analysis 6 was made is from the laccolith east of Tjamba. It resembles a medium-grained gabbro, and consists largely of augite, with less olivine and magnetite, a small amount of biotite, and considerable orthoclase, each crystal having a clouded core of altered plagioclase. There is also a zeolite, which probably replaces nephelite. The shonkinite, from which analysis, 7, was made, is much richer in biotite than the rock from East of Tjamba, is free from olivine, has abundant augite and orthoclase, besides clouded portions with a somewhat radiate structure, probably an intergrowth of feldspar and nephelite, now altered. There is also some zeolite as an alteration product. The shonkinite of analysis 8 is rich in augite and magnetite, with less feldspar, in part orthoclase, in part alkalic plagioclase, both with marginal intergrowths of a mineral with still lower refraction, which is probably altered nephelite. Analysis 10 is of another shonkinite with much augite. and orthoclase, and a zeolite which replaces pseudoleucite or nephelite.

The leucitophyre from Batuku, whose analysis is 9 has abundant phenocrysts of augite and fresh leucite, in a groundmass of small leucites and augites, with some plagioclase, magnetite, and secondary chlorite and zeolite. Analysis 11 is of a leucitophyre exceptionally rich in calcium oxide, and low in alumina. The rock has abundant phenocrysts of augite and fresh leucite, in a groundmass of small leucites, augite, anhedral wollastonite, and magnetite. The norm contains an unusually high percentage of wollastonite.

Analysis 12 is exceptional because of the low alumina and relatively high amount of potash. The rock from which it was made is an aphanitic porphyry, consisting mainly of augite with less olivine, as phenocrysts in a groundmass of augite, magnetite, and leucite. There is over 80% of mafic minerals, so that the rock is a leucitic limburgite, or a highly mafic leucitite. It is clearly an extremely mafic phase of leucitophyre, and since it does not correspond to any lava, so far described and analyzed, it seems advisable to name the rock batukite after the locality in which it occurs.

TABLE OF CHEMICAL ANALYSIS AND NORMS OF LAVAS FROM CELEBES

	1	2	3	4	5	6	7	8	9	10	11	12
SiO_2.....	58.33	56.59	50.72	49.42	47.00	48.06	46.27	46.32	46.45	46.45	45.70	47.72
Al_2O_3....	20.37	20.15	17.44	18.04	16.65	12.86	15.10	12.27	13.01	14.81	7.58	4.65
Fe_2O_3....	1.48	1.97	2.96	2.85	3.37	6.05	4.30	6.62	5.67	5.73	5.72	4.84
FeO.....	0.75	1.31	3.68	4.24	4.25	4.50	4.57	5.07	5.21	4.47	4.23	3.97
MgO....	0.30	1.09	2.98	3.16	2.58	3.26	6.70	6.34	6.44	4.97	4.76	16.98
CaO.....	2.81	3.81	5.18	6.66	6.28	12.72	8.27	12.45	11.74	9.55	21.66	15.43
Na_2O....	7.14	5.78	3.22	1.52	3.70	2.22	2.60	2.51	1.75	4.31	1.01	0.88
K_2O.....	6.17	4.63	7.74	9.24	6.90	4.71	5.04	3.49	4.82	4.25	3.79	2.27
H_2O+...	1.37	2.32	2.13	1.08	2.47	2.82	2.26	1.34	1.68	1.59	2.41	1.54
H_2O-...	0.18	0.85	0.39	1.07	0.44	0.48	0.53	0.28	0.43	0.54	0.99	0.43
TiO_2....	0.27	0.52	1.14	0.58	1.21	0.91	1.64	1.23	1.22	1.01	0.83	0.46
ZrO_2....	0.00	0.00	0.00	0.00	0.00	0.01	tr	0.02	0.01	0.00	tr	0.00
CO_2......	0.10	0.00	0.24	0.03	3.59	0.01	0.53	0.01	0.22	0.00	0.18	0.00
P_2O_5.....	0.11	0.11	1.14	0.92	0.82	0.69	1.03	1.18	0.67	0.92	0.65	0.41
Cl......	0.13	0.14	0.13	0.09	0.05	0.02	0.09	0.08	0.06	0.06	0.05	0.08
F.......	0.05	0.05	0.08	0.07	0.06	0.05	0.06	0.09	0.05	0.06	0.03	0.06
S.......	0.07	0.05	0.08	0.09	0.08	0.03	0.12	0.04	0.06	0.13	0.03	0.07
Cr_2O_3...	0.00	0.02	0.02	0.00	0.01	0.01	0.00	0.03	0.02	0.01	0.05	0.11
MnO....	0.38	0.37	0.37	0.27	0.60	0.29	0.55	0.55	0.33	0.54	0.33	0.15
BaO.....	0.05	0.02	0.20	0.38	0.14	0.24	0.19	0.21	0.17+	0.71 $(\frac{2}{2})$	0.04	0.16
SrO.....	0.00	0.02	0.07	0.07	0.07	0.02	0.09	0.19	0.12	0.12	0.15	0.04
	100.07	99.80	99.93	99.58	100.29	99.96	99.94	100.32	100.13	100.23	100.19	100.25

NORMS

	1	2	3	4	5	6	7	8	9	10	11	12
or.......	36.70	27.24	45.59	40.59	40.59	27.80	29.47	20.57	28.36	26.13	11.68	11.68
ab......	35.11	42.44	10.48		3.14	10.48	7.34	7.86				
an......	5.28	15.29	10.29	15.01	8.34	11.40	14.73	12.23	13.34	8.34	5.28	1.95
ne......	13.63	3.41	9.09	6.82	15.34	4.26	7.95	7.10	7.95	13.06	4.54	4.26
lc.......				10.90						9.59	8.28	1.31
di.......	2.72	2.19	6.48	10.88	14.28	22.18	16.06	33.87	32.42	26.68	30.17	56.54
wo......	1.86					8.12					24.94	
ol.......		1.56	5.58	5.44	2.56		8.91	1.99	2.96	1.70		13.31
mt......	2.09	3.02	4.18	4.18	4.87	8.82	6.26	9.51	8.35	8.35	8.35	7.19
il.......	0.64	0.91	2.13	1.22	2.28	1.67	3.04	2.28	2.28	1.98	1.52	0.91
ap......	0.34	0.34	2.69	2.02	2.02	1.68	2.35	2.69	1.68	2.02	1.68	1.01
etc......	1.95	3.47	3.14	2.50	6.77	3.45	3.59	1.89	2.53	2.39	3.78	2.22
	100.32	99.87	99.65	99.56	100.19	99.86	99.70	99.99	99.87	100.24	100.22	100.38

1 Trachytic phonolite: beemerose-miaskose. I′. (5) 6. 1(2). (3) 4. Summit, Bulu Saraung. E. W. Morley.

2 Pseudo-leucite-trachyte: pulascose-laurvikose. I′. 5. 2. (3)4. East of Malawa. E. W. Morley

3 Pseudo-leucite-trachyte: ciminose-monzonose. II. 5(6). 2. (2)3. Stream S. W. of Bulu Saraung. E. W. Morley.

4 Leucitophyre: vicose. II. 6. 2. 2. Batuku. E. W. Morley.

5 Minette: borolanose. II. 6. ′2. 3. Dike, stream S. W., of Bulu Saraung. E. W. Morley.

6 Skonkinite: lamarose. III. 5′. 2′. 3′. Laccolith east of Tjamba. E. W. Morley.

7 Shonkinite: ourose-shonkinose. (II)III. (5)6. 2(3). 3. Laccolith, road S. of Bulu Saraung. E. W. Morley.
8 Shonkinite: ourose-shonkinose. III. (5)6. 2(3). 3. Stream, Malawa. E. W. Morley.
9 Leucitophyre: ourose-ottajanose. III. '6. (2)3. 2(3). Stream, Batuku. E. W. Morley.
10 Shonkinite: kamerunose-cascadose. 'III. (6)7. 2. 3(4). Laccolith E. of Malawa. E. W. Morley.
11 Leucitophyre: ————. IV. '2. $_1$. 1. '$_4$. 2(3). Stream, Malawa. E. W. Morley.
12 Batukite, leucite-limburgite, brunose-belcherose. IV. 1(2). $_2$. 1. $_{2\cdot(3)}$. 1(2). Batuku. E. W. Morley.

ON THE NON-EXISTENCE OF NERVOUS SHELL-SHOCK IN FISHES AND MARINE INVERTEBRATES

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Experiments made at Tortugas, Florida, during the summer of 1917 indicate that the nervous systems of fishes and invertebrates are remarkably resistant to the injurious effects of sudden explosive shocks transmitted through the water.

Many experiments were made upon the Scyphomedusa *Cassiopea xamachana*. The medusae were paralyzed by removing their marginal sense organs, and then a ring-shaped strip of subumbrella tissue was set into pulsation by an induction shock; thus producing a single neurogenic contraction which travels through the circuit-shaped strip of tissue at a uniform rate of speed, provided temperature, salinity and other factors remain unchanged. It is thus possible accurately to ascertain not only the rate of nerve conduction but also the peculiar individual characteristics of the wave in each pulsating ring.

These rings were placed in a light silken bag immersed about 10 feet below the surface of the sea; and then a half stick of dynamite was exploded within 3 feet of them. This, however, produced no effect either upon their rates or the character of their pulsation waves, although fishes possessing swim-bladders were killed within 10 feet, and injured so that they turned ventral side uppermost within 20 feet of the exploding dynamite.

When the pulsating rings were placed in glass jars or tin cans, partially filled with air, the containers were crushed or shattered by the explosion and much mechanical injury sustained by the medusa rings, which however, could at once be restored to normal pulsation by an induction shock, if their pulsations had ceased. It was also observed that the lacerated area regenerated at a normal rate.

Prof. J. F. McClendon suggested that fishes with swim-bladders might